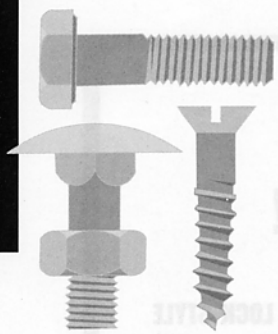

Performance Testing of All-metal Commercial Locknuts

by Joe Greenslade

Locknuts are those types of nuts which are designed to have a "prevailing torque" when they are rotated on an externally threaded part. Prevailing torque is the resistance a fastener has to being turned as a result of friction between mating external and internal threads. This friction is the result of some amount of controlled deformation of the nut that creates interference between the nut's thread and a mating external thread. The performance requirements for all-metal commercial locknuts are governed by the Industrial Fastener Institute specification IFI-100/107 dated April 1, 2002. This specification covers all of the requirements for all-metal locknuts including dimensions, chemistry, hardness, proof load, clamp load, and prevailing torque. This article explains the testing requirements for all-metal locknuts covered by IFI-100/107 only. The April 1, 2002 issue of IFI-100/107 is different from the 1987 version in three significant areas:

1. The requirements for the number of removals to test have been reduced from five to three.
2. The "First Install" maximum torque values have been raised significantly.
3. The prevailing torque test has been simplified to require only one torque reading during each removal cycle instead of two readings as required in the previous revisions of this standard.

The performance of locknuts that are manufactured using non-metallic rings, inserts, or patches is covered in IFI-155, January 3, 2002 for inch nuts and IFI-555, January 2002 for metric nuts and are not dealt with in this article.

There are three grades of hex locknuts (A, B, and C) and two grades of hex flange locknuts (F and G). The requirements for locknuts differ depending up on their grade. Table 4 of the IFI specification provides the requirements for proof load and hardness. Tables 5A (see page XX) and 5B (see page XX) provide the requirements for proof load, clamp load, and prevailing torque. A comparison of columns in Tables 5A and 5B shows that the requirements for Grade B hex locknuts are the same as for Grade F hex flange locknuts and Grade C hex locknuts are the same as for Grade G hex flange locknuts. Partial excerpts from these tables are shown in this article. The entire specifications can be purchased directly from the Industrial Fastener Institute (216-241-1482 or www.ifi-fasteners.org).

A brief explanation of the basic hardness and performance requirements of this specification follows:

HARDNESS TESTING

The hardness of locknuts is to be taken on the top surface of the nut at a position located midway between the corner of the nut and its internal thread. This top surface should be ground slightly to remove any plating and decarburization prior to doing the hardness test.

PROOF LOAD

This test is required to determine if a locknut can support the tensile load it is designed to support without stripping or deforming the threads.

This test is conducted by assembling a locknut on a test bolt in a tensile testing machine and applying a specified axial load. The test bolt is to have a class 2A thread and have a yield strength greater than the locknut's proof load requirement. The torque needed to assemble the locknut on the test bolt must not exceed the "First Install" torque specified for the locknut in Tables 4 and 5. A

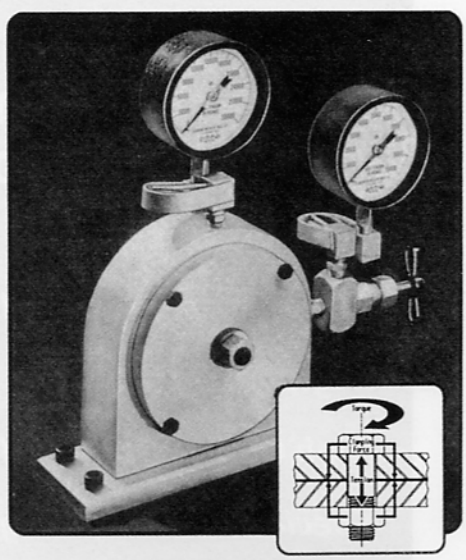

FIGURE 1. Tension Tester

Joe Greenslade has been active in the fastener industry since 1970. He has held positions with major fastener producers in sales engineering, marketing, product design, manufacturing management, and research and development management.

Mr. Greenslade holds twelve U.S. patents on various fastener related products. He has authored over 136 trade journal articles on fastener applications, manufacturing and quality issues. He is one of the fastener industry's most frequent speakers at trade association meetings and conferences. He is the youngest person ever inducted to the Fastener Industry Hall of Fame.

Mr. Greenslade is active in numerous fastener industry associations and societies holding office in several of them.

In addition to guiding the activities of Greenslade & Company, Mr. Greenslade works as a consultant with fastener suppliers and end users on product design, applications engineering, and quality issues. In this capacity he works to resolve fastener applications problems, to help select the best fastening approaches in new product designs, to assist in the standardization of fasteners used within an organization, and to provide training on various aspects of fastening technology and fastener quality assurance. He also serves as Expert Witness in litigation involving fastener related issues.

Table 5A Proof Loads, Clamp Loads, and Prevailing-Torques for Coarse Thread Series Grades A, B, and C Hex Nuts and Grades F and G Hex Flange Nuts

Nut Size and Threads per Inch	Grade A Nuts		Grade B Nuts		Grade C Nuts		Prevailing-Torque			Grade F Nuts		Grade G Nuts	
	Proof Load lb	Clamp Load lb	Proof Load lb	Clamp Load lb	Proof Load lb	Clamp Load lb	First Install max lb. in	First Removal min lb. in	Third Removal min lb. in	Proof Load lb	Clamp Load lb	Proof Load lb	Clamp Load lb
Coarse Thread Series													
No. 4 - 40	540	250	720	380	910	550	4.0	1.0	0.2				
6 - 32	820	370	1,100	580	1,350	810	8.0	1.5	0.5				
8 - 32	1,250	580	1,700	900	2,100	1,250	12.0	2.0	0.5				
10 - 24	1,550	720	2,100	1,100	2,600	1,550	17	2.5	1.0				
12 - 24	2,200	1,000	2,900	1,550	3,650	2,200	27	3.5	1.0				
1/4 - 20	2,900	1,300	3,800	2,000	4,750	2,850	40	5.0	1.5	3,800	2,000	4,750	2,850
5/16 - 18	4,700	2,150	6,300	3,350	7,850	4,700	80	8.0	2.5	6,300	3,350	7,850	4,700
3/8 - 16	7,000	3,200	9,300	4,950	11,600	6,950	110	12.0	4.0	9,300	4,950	11,600	6,950
7/16 - 14	9,550	4,400	12,800	6,800	15,900	9,600	135	17	5.0	12,800	6,800	15,900	9,600
1/2 - 13	12,800	5,850	17,000	9,050	21,300	12,800	204	22	7.5	17,000	9,050	21,300	12,800
9/16 - 12	16,400	7,550	21,800	11,600	27,300	16,400	300	30	10.0	21,800	11,600	27,300	16,400
5/8 - 11	20,300	9,300	27,200	14,500	33,900	20,300	420	39	12.5	27,200	14,500	33,900	20,300
3/4 - 10	30,000	13,800	40,100	21,300	50,100	30,100	540	58	20	40,100	21,300	50,100	30,100
7/8 - 9	41,600	12,400	55,400	29,500	69,300	41,600	840	88	30				
1 - 8	54,500	15,000	72,700	38,700	90,900	54,600	1080	120	40				
1-1/8 - 7	68,700	18,900	80,100	42,100	115,000	69,000	1200	150	50				
1-1/4 - 7	87,200	24,000	101,700	53,500	145,000	87,000	1320	188	60				
1-3/8 - 6	104,000	28,700	121,300	63,800	173,000	104,000	1620	220	70				
1-1/2 - 6	126,000	34,800	147,500	77,600	211,000	127,000	1800	260	90				

NOTE:
Clamp loads for Grades A, B and C prevailing-torque nuts respectively equal 75 percent of the proof loads specified for Grades 2, 5 and 8 bolts in SAE J429. Clamp loads for Grades B and C prevailing-torque nuts also respectively equal 75 percent of the proof loads specified for ASTM A449 and ASTM A354 Grade BD bolts. Clamp loads for Grades F and G prevailing-torque nuts respectively equal 75 percent of the proof loads specified for Grades 5 and 8 bolts in SAE J429 and are also respectively equal to 75 percent of the proof loads specified for ASTM A449 and ASTM A354 Grade BD bolts.

Table 5B Proof Loads, Clamp Loads, and Prevailing-Torques for Fine Thread Series Grades A, B, and C Hex Nuts and Grades F and G Hex Flange Nuts

Nut Size and Threads per Inch	Grade A Nuts		Grade B Nuts		Grade C Nuts		Prevailing-Torque			Grade F Nuts		Grade G Nuts	
	Proof Load lb	Clamp Load lb	Proof Load lb	Clamp Load lb	Proof Load lb	Clamp Load lb	First Install max lb. in	First Removal min lb. in	Third Removal min lb. in	Proof Load lb	Clamp Load lb	Proof Load lb	Clamp Load lb
Fine Thread Series													
No. 4 - 48	600	270	790	420	990	600	4.0	1.0	0.2				
6 - 40	900	420	1,200	640	1,500	900	8.0	1.5	0.5				
8 - 36	1,350	610	1,750	930	2,200	1,300	12.0	2.0	0.5				
10 - 32	1,800	840	2,400	1,300	3,000	1,800	17	2.5	1.0				
12 - 28	2,300	1,050	3,100	1,650	3,900	2,350	27	3.5	1.0				
1/4 - 28	3,300	1,500	4,350	2,300	5,450	3,250	40	5.0	1.5	4,350	2,300	5,450	3,250
5/16 - 24	5,200	2,400	6,950	3,700	8,700	5,200	80	8.0	2.5	6,950	3,700	8,700	5,200
3/8 - 24	7,900	3,600	10,500	5,600	13,200	7,900	110	12.0	4.0	10,500	5,600	13,200	7,900
7/16 - 20	10,700	4,900	14,200	7,550	17,800	10,700	135	17	5.0	14,200	7,550	17,800	10,700
1/2 - 20	14,400	6,550	19,200	10,200	24,000	14,400	204	22	7.5	19,200	10,200	24,000	14,400
9/16 - 18	18,300	8,350	24,400	13,000	30,400	18,300	300	30	10.0	24,400	13,000	30,400	18,300
5/8 - 18	22,900	10,500	30,700	16,300	38,400	23,000	420	39	12.5	30,700	16,300	38,400	23,000
3/4 - 16	33,600	15,400	44,800	23,800	56,000	33,600	540	58	20	44,800	23,800	56,000	33,600
7/8 - 14	45,800	12,600	61,100	32,400	76,400	45,800	840	88	30				
1 - 14	61,100	16,800	81,500	43,300	101,900	61,100	1080	120	40				
1 - 12	59,700	16,400	79,600	42,300	99,500	59,700	1080	120	40				
1-1/8 - 12	76,900	21,200	89,900	47,500	128,000	76,800	1200	150	50				
1-1/4 - 12	96,600	26,600	113,000	59,700	161,000	96,600	1320	188	60				
1-3/8 - 12	118,000	32,500	138,000	72,900	197,000	118,000	1620	220	70				
1-1/2 - 12	142,000	39,100	166,000	87,700	237,000	142,000	1800	260	90				

NOTE:
Proof loads for Grades F and G flange prevailing-torque nuts are based on 120,000 psi and 150,000 psi, respectively.

flat test washer is to be placed under the nut so that the pulling force is parallel with the axis of the thread. A pulling force is applied to the test bolt by the tensile tester equal to the proof load requirement of the locknut being tested. After the required force is achieved the pressure is then released.

When all of the pressure is off of the assembly the locknut must be able to be removed from the test bolt with a removal torque no greater than the torque required to assemble it at the beginning of the test. If the removal torque exceeds the initial assembly torque the locknut is to be rejected because this is evidence that its thread has been deformed during the proof test, which is unacceptable.

CLAMP LOAD

This test is required to determine if a locknut can be tightened on a bolt and achieve its required clamping force without failing the assembly. Assembly failure can occur by stripping the locknut's thread or by stripping or breaking the bolt. The achievement of desired clamping force is the critical requirement from a practical standpoint in assuring that the fastening system will do its intended job in providing a tight joint.

This test is conducted using Torque-Tension Tester (see Figure 1 on page 48). A test bolt having a tensile strength greater than the nut's proof load requirement, a class 2A thread and a phosphate and oil finish is placed through the tester. A hardened, unplated, and unlubricated washer is put on the bolt, and then the locknut is rotated onto the bolt. The bolt and washer are to be prevented from rotating during this test.

After the parts are assembled as explained above, the locknut is tightened on the bolt, against the washer, until the Torque-Tension Tester indicates the required Clamp Load as specified in the standard in Tables 5A or 5B. As an example, a 1/2-13 Grade B locknut is to be tightened until the Torque-Tension Tester indicates 9,050 pounds of force.

The driving torque required to rotate the locknut on the bolt until it seats against the washer must not exceed the value shown as "First Install" in the same table. This maximum installation torque

continued on page 60

value for the 1/2-13 Grade B locknut is 204 inch pounds.

If the locknut can be driven on the test bolt until it contacts the test washer with a torque no greater than that listed under “First Install” torque, and the specified “Clamp Force” can be achieved without failing the locknut or bolt, the “Clamp Load” requirement has been met.

Prevailing Torque

The prevailing torque test is required to determine if a locknut can be installed without exceeding a maximum installation value and can provide a resistance to rotating loose through at least 3 installation and removal cycles without going below specified minimum prevailing torque values.

The prevailing torque test is generally a continuation of the “Clamp Force” test. The test bolt used should be a length such that when the locknut is properly seated it has 6 to 9 threads exposed above the top of the locknut. The “First Install” torque is recorded when the locknut is initially installed on the bolt while performing the clamp load test.

After the clamp force is achieved the locknut is rotated in the loosening direction until the load on the Torque-Tension Tester indicates zero force. During the next 360 degrees of loosening rotation of the locknut the lowest torque reading observed is recorded. This torque value must exceed the minimum requirements listed under “First Removal” in Tables 5A or 5B. The requirement for a 1/2-13 Grade B locknut for “First Removal” in Table 5A is 22 inch pounds of torque. After recording the loosening torque value in the first 360 degrees, the loosening rotation is continued until the locking area of the locknut is disengaged from the test bolt.

The locknut then driven on the test bolt again until the specified clamping force is achieved. The locknut is then removed again until the locking area is disengaged as done previously. This is repeated once more. On the last time, which is the “Third Removal”, the lowest torque value observed during the 360 degree removal cycle is recorded. The results are to be compared to the requirements listed in Tables 5A or 5B. The recorded removal torque value for the “Third Removal” must exceed the specified minimum. The minimum prevailing torque requirement on the “Third Removal” for a 1/2-13 Grade B locknut is 7.5 inch pounds.

Sample Size

The number of samples to be tested to determine the acceptability of a lot of locknuts should be determined by the sampling plan for destructive testing in Table 3 of ANSI/ASME B18.18.2, 1987 that indicates the following:

Lot Size	Sample Size
1 - 4,999 Pieces	2
1001 – 5000 Pieces	4
5001 – 250,000 Pieces	8

When doing the clamp load and prevailing torque test, a new test bolt should be used with each new locknut sample. Test washes can be reused up to five times on each side unless surface damage on the face of the washer is observed, in which case the washer should not be used for any more tests.

Conclusion

The loosening of fasteners during a product’s use has always been a major concern for fastener users. This has led to wide use of many varieties of all-metal locknuts in an attempt to reduce product maintenance and failure costs resulting from loosening fasteners. Fastener suppliers and users need to realize that just because a product is sold under the description of “LOCKNUT” it does not necessarily mean that those nuts meet the specified requirements that are established in the IFI-100/107 standard to assure proper anti-loosening performance.

The only way a fastener supplier or user can be assured that a given lot of all-metal locknuts will provide the load carrying and anti-loosening performance they expect is to properly and thoroughly evaluate these products according to the requirements of the IFI 100/107, April 1, 2002 specification. Only after the subject locknuts have passed the proof load, clamp load, and prevailing torque requirements can they be used with confidence that they will perform as intended. Assumptions about locknut acceptability can lead to costly product maintenance costs and/or possibly liability claims.